

CHAPTER 17

PNEUMATIC CONTROLS

17-1. Pneumatic control design features

Pneumatic controllers for the most part rely on compressed air as described in the previous chapter. Additional air dryers and filters may be added locally in the area of interest in addition to those back at the compressor station.

a. Components. The next stage in control is the pressure regulator or regulators. At this point one or more operating pressures are set for the equipment in the area with each operating pressure having its own dedicated line. From this line(s) various pieces of equipment can operate. The simplest would be pressure gauges that measure the process relative to atmosphere or another set pressure. Next would be control switches that would activate either electrical circuits or pneumatic circuits based on pressure set point or set points. For example, the reset state could be set at a different set point from the initiation set point. Then there are thermostats, a control switch that operates based on the process temperature or in another case the outside temperatures to which the process is exposed. See figure 17-1 for an example of this case. At the next level are pressure transmitters and controllers. This class of service acts as a pneumatic amplifier to send pressure changes over greater distances and/or to generate enough energy to operate a valve or piston. There are many variations to these devices to allow for feedback proportional and derivative control. For maintenance review, site process drawings, data sheets, and manufacturers' information should be used.

b. Applications. Tools and appliances driven by compressed air are known as pneumatic devices. Examples of these devices are rock drills, jackhammers, spray painters, and air brakes. In some cases, air suction instead of compression is used to operate the tool or appliance, as in the familiar vacuum cleaner. Pneumatic devices are flexible, efficient, and safe. An air device creates no sparks. This is an important consideration for work in dangerous areas. Air compressors used in pneumatic tools and appliances may be either reciprocating--that is, driven by the up-and-down motion of a piston in a cylinder--or rotary, in which the air is compressed by a device similar to a centrifugal or axial pump.

17-2. Pneumatic control systems major components

Pneumatic control systems are comprised of the following major components.

a. Air motors. Pneumatic devices are operated by two types of air motors: rotary and reciprocating. These air motors are the opposite of reciprocating or rotary air compressors. In a rotary device, also known as an air turbine, compressed air enters the motor housing, pushes on the rotary blades, and rotates a central shaft or spindle. Small devices can be run at speeds up to 30,000 revolutions per minute. Reciprocating pistons are driven as compressed air enters the cylinder, expands, and forces the piston to move. The return stroke is triggered either by compressed air pushing on the other side of the piston or by spring action. Pneumatic tools are commonly supplied with compressed air at or above 100 pounds per square inch (690 kilopascals). Air motors do not become hot when overloaded and can stand repeated stalling and rapid reversals without damage. Pneumatic tools of different sorts are used for a variety of purposes. Portable pneumatic tools are normally powered by rotary air motors and include grinders, buffers, drills, screwdrivers, chipping hammers, and various specialty tools such as paint mixers, concrete

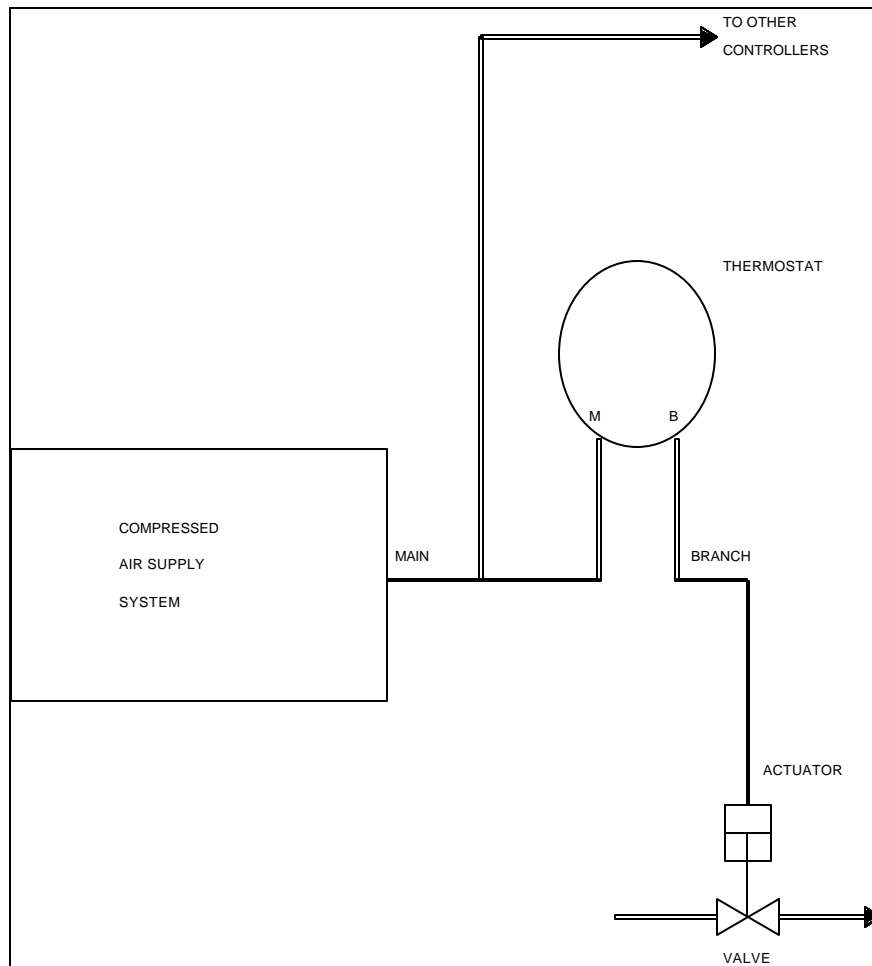


Figure 17-1. Basic compressed air supply to pneumatic control system

vibrators, and spikedrivers. Rock drills are heavy-duty machinery used for mining and rock excavation and are powered by reciprocating piston motors. Here, a high-carbon steel drill is held loosely in a chuck at the end of a cylinder and is struck by rapid blows from the freely moving piston. Major pneumatic devices include jackhammers, pneumatic drills and wrenches, spray guns, pneumatic conveyor systems, and brake systems. They have wide application in home and industrial use. Jackhammers, or paving breakers, are powered by a reciprocating piston that strikes a solid street drill that usually has a wedge-shaped end. Heavy jackhammers are used to break up road surfaces, concrete, and boulders; lighter versions are used on light concrete floors, frozen earth, and ice.

b. Instrumentation. Instruments are the means for monitoring or measuring physical variables. The basic element of instrumentation is the transformation of one form of energy into another form. Producing meaningful information from physical variables requires conversion and processing. Electronic instruments require that physical variables be converted to electrical signals through a process of *transduction*, followed by signal *conditioning* and signal *processing* to obtain useful results.

(1) The measured parameter can be one of many physical variables; the type depends on the application. For example, in process control, typical measured parameters can include pressure, temperature, and flow.

(2) Transducers convert one form of energy to another. To be useful for an electronic instrument, a transducer must produce an electrical output such as voltage or current to allow required signal conditioning and signal processing steps to be completed. A variety of transducers are available to meet measurement requirements and can be compared based on their operating principles, measurement range, interface design, and reliability.

c. Process control. Process control typically involves some mechanical system that needs to be operated in such a fashion that the output of the system remains within its design operating range. The objective of a process control loop is to maintain the process at the set point under the following dynamic conditions.

- (1) The set point is changed.
- (2) The load on the process is changed.
- (3) The transfer function of the process is changed or a disturbance is introduced.

d. Closed-loop operation. The classical control system representation is a feedback-loop system. A feedback (or closed-loop) system contains a process, a sensor, and a controller. A process is a system that produces a motion, a temperature change, a flow, a pressure, or many other actions as a function of the actuator position and external inputs. The output of the process is called the process value. If a positive action in the actuator causes an increase in the process value, then the process is called direct acting. If positive action in the actuator decreases the process value, it is called reverse acting.

(1) A sensor is a pneumatic, fluidic, electronic or other device that produces some kind of signal indicative of the process value.

(2) The set point is the desired value for a process output. The difference between the set point and the process value is called the process error.

(3) A controller sends signals to an actuator to effect changes in a process. The controller compares the set point and the process value to determine the process error. It then uses this error to adjust the output and bring the process back to the set point. The controller *gain* dictates the amount that the controller adjusts its output for a given error.

(4) An actuator is a pneumatic, fluidic, electric, or other device that performs any physical action that will control a process.

17-3. System operation

As discussed in the previous sections, the major operation of the pneumatic control system is controlled by the compressed air system. Various variables can affect the proper operation and require strict control and maintenance processes.

a. Disturbances. An external disturbance is any effect that is unmeasured or unaccounted for by the controller.

b. Time constant. The time constant of a sensor or process is a quantity that describes the dynamic response of the device or system. Often the time constant is related to the mass of an object or other dynamic effect in the process. For example, a temperature sensor may have a protective sheath around it that must first be warmed before the sensor registers a change of temperature. Time constant can range from seconds to hours.

c. *Dead time.* The dead time or lag time of a process is the time between the change of a process and the time this change arrives at the sensor. The delay time is not related to the time constant of the sensor, although the effects of the two are similar. Large dead times must be properly treated by the control system to prevent unstable control.

d. *Hysteresis.* Hysteresis is a characteristic response of positioning actuators that result in different positions depending on whether the control signal is increasing or decreasing.

e. *Dead band.* The dead band of a process is that range of the process value in which no control action is taken. A dead band is usually used in two-position control to prevent “chattering” or in split-range systems to prevent sequential control loops from fighting each other.

f. *Control point.* The control point is the actual, measured value of a process (i.e., the set point + steady-state offset + compensation). A direct-acting process will increase in value as the signal from the controller increases. A reverse-acting process will decrease in value as the signal from the controller increases.

g. *Stability.* The stability of a feedback control loop is an indication of how well the process is controlled or, alternatively, how controllable the process is. The stability is determined by any number of criteria, including overshoot, settling time, correction of deviations due to external disturbances, etc.